Fermi National Accelerator Laboratory

United States Compact Muon Solenoid Collaboration

US-CMS CATHODE STRIP CHAMBER QUALITY ASSURANCE PLAN
Version 2

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Purpose

The purpose of this Quality Assurance Plan is to describe Fermilab's effort on the Cathode Strip Chamber portion of the Compact Muon Solenoid Project. This document is formatted following the criteria defined in DOE O 414.1A Quality Assurance, and the Technical Division Quality Management Program, TD-2010.

Each section of this document begins with a policy statement for the Technical Division. The CMS-CSC Project adheres to the TD policies, unless otherwise stated.

Scope

The description and requirements in this plan are generally applicable to all activities included in the CSC portion of the CMS Project. All the detailed requirements that are specified in the TD Quality Management Program are not repeated here. The CMS Project Management has assigned the responsibility for execution of the CSC Project to the Technical Division.

1.0 Program

1.1 Policy

The policy of the Technical Division is to develop, document, and maintain it's quality management program, so that the Division may satisfy the needs of its customers.

1.2 Mission

The mission of *Fermi National Accelerator Laboratory* is:

"Advancing the understanding of the fundamental nature of matter and energy by providing leadership and resources for qualified researchers to conduct basic research at the frontiers of high energy physics and related disciplines."

The mission of the *Technical Division* is:

"The development, design, fabrication or procurement, and testing of accelerator and detector components."

The mission of the *Cathode Strip Chamber Project* at Fermilab is to:

1) Design, build, and test Cathode Strip Chambers;
2) Prepare component kits for assembly by other collaborating institutions;
3) Deliver compliant chambers to US Fast Sites for electronics integration.

1.3 Objectives, Goals and Functional Responsibilities

[1] To design and fabricate required detectors for the CERN LHC.

The Engineering & Fabrication Department is responsible for the design of the manufacturing tooling and the chambers that are required in this project.

[2] To procure, inspect, inventory, and deliver the various materials needed for this project.

The Material Control Department is responsible for these functions. The Engineering & Fabrication Department interfaces with the Material Control Department and other groups, as required, to assist the procurement section of Fermilab in procuring the needed material.

Inspection of the procured materials will be required. See section 8.0 for details. The storage and inventory of the components for the chambers may be required in some cases.

[3] To test the chambers.

All the detectors that are to be fabricated will be tested for functionality. See section 8.0 for specifics on Inspection and Acceptance Testing.

[4] To oversee the scheduling of milestones, to budget and control cost, and to report to the Level 3 manager timely status reports, as required by the project office.

These functions are assigned to the Fermilab CSC Site Manager & CSC Project Engineer, who are assisted by their staff and other project personnel. This includes reporting on the resource requirements and status of the project to the Technical Division Head.

[5] To create and maintain a Quality Assurance program.

Although quality is the responsibility of every Fermilab employee, the task of creating and maintaining the QA program is assigned to the Quality Assurance Officer.

[6] To perform the required material development for this project.

This task has been assigned to the Material Development Laboratory in the Engineering & Fabrication Department, on an as-needed basis.

[7] To provide a qualified staff for the performance of this project and to provide the needed laboratory work space.

This function is the responsibility of the Technical Division Head, acting on input supplied by the CSC Site Manager & CSC Project Engineer.

1.4 Organization Structure

Attached is the organizational chart for the CMS-CSC Project (see Attachment I). The organizational structure/responsibilities for collaborative groups, i.e. Universities of Florida and Wisconsin, are defined using Memorandums of Understanding (MoU's) and Statements of Work (SoW's). The signed approved original MoU’s and SoW's are maintained by the US-CMS project office.

Although the CMS Project is conducted as a collaborative team effort, the CMS-CSC Project Manager has ultimate responsibility for the completion of the project.

Clear and frequent communication is always encouraged among the project participants, and is critical to the success of the CMS-CSC Project. Informal communication via notes, phone calls, electronic mail, and informal discussions are exchanged frequently between the participants. This information flow encourages the exploration of the viability of plans and solutions, and allows for the resolution of any issues that arise. Although it is not a project requirement, the distribution of copies of informal correspondence to all participants is desirable to keep everyone apprised of the most current information available.

Management's systems for performing and assessing adequacy of work on the CMS-CSC's, including activities that relate to planning, scheduling, and cost control are described in detail in the following documents:

1. CMS Project Management Plan
2. Technical Division Quality Management Program
3. Technical Division Self-Assessment Program

1.5 Roles, Responsibility, and Authority

1.5.1 Project Site Manager, CSC Project

- Project Site Manager is responsible to the CMS Level 3 Manager for delivering acceptable chambers and chamber kits.
  - ♦ Manage the third level of the WBS for detectors with accepted Fermilab practices.
  - ♦ Record control account and schedule status on a timely basis.

- Represent the detector project to the collaborators and L3 and above, providing them, as required and funded, with resources, e.g. staffing, space, machine shop priority, et cetera.
- Ensure that requirements and specifications are provided to appropriate Technical Division groups on a timely basis.
- Implement the QA Plan.
- Assure the quality of the delivered products.

1.5.2 Engineering and Fabrication Department Head

Responsible for providing support, oversight, direction, and feedback to project managers.

1.5.3 Quality Assurance Officer

- Responsible for the creation and maintenance of the Quality Assurance Plan.
- Responsible for providing support to the CMS-CSC Project staff throughout the project.

1.5.4 Technical Division Head

Provide support to project personnel, and aid in solving problems that cannot be solved on a lower level.

1.6 Organizational Interface

1.6.1 CMS Project Office/TD-HQ

- Communicate project status when changes occur and periodic, e.g. monthly, reports.
- Determine staffing requirements for CMS-CSC Project within TD
- Resolve resource allocation issues, e.g. draftsman assignments, machine shop priorities, and space allocation.

1.6.2 CMS Project Office/Fermilab Business Office

- Procurement representative will attend weekly CMC-CSC design/fabrication meeting with CMS Project Managers and TD

1.6.3 CMS Project Office/Level II and Level III Managers

- Develop requirements and specifications to fulfill the goals of the CMS Project. The CMS Project Manager will approve requirements and specifications. Attachment III defines this interface.
- Conduct weekly meetings with Fermilab Business Manager and CMS Project Manager to discuss issues and procurement status

2.0 Personnel Training and Qualifications

2.1 Policy

The policy of the Technical Division is to hire and maintain personnel who posses the appropriate level of skill, experience, and academic qualifications to support the achievement of the CMC-CSC's mission.

2.2 Training

In-house training is provided to ensure that an appropriate level of skills, knowledge, expertise, and experience are available to accomplish the stated mission and objectives.

Training may come from several sources such as mentoring provided by physicists, engineers, supervisors, lead personnel, consulting firms, technical operating manuals, and other sources. Job-related training records of all assigned personnel, for work related to the CMS Project, are maintained by the respective supporting organization.

2.3 Qualifications

Qualifications for personnel working on the CMS are based upon the responsibilities of the position and project needs, which define the level of education, extent of work experience, knowledge and specific skill requirements.

3.0 Quality Improvement

3.1 Policy

The policy of the Technical Division is to continuously improve in all areas and activities for which it is responsible.

3.2 Quality Implementation

- This document is the guide for the development and implementation of quality assurance for the CMS-CSC Project, and is used to support the achievement of the stated mission and performance objectives. This document further ensures that appropriate procedures are in place that describes the extent and method of how the quality requirements will be implemented.
- It is the intent of the CMS Project Manager that all activities be performed at a level of quality appropriate to achieving the scientific, technical, operational, and administrative objectives.

3.3 Quality Responsibilities

- All personnel performing a function at Fermilab are responsible for quality and are encouraged to promptly report conditions adverse to quality such as deviations, deficiencies, failures, defective items or processes, and nonconformances, to the appropriate level of management.
- Personnel closest to the daily operation or activity are in the best position to understand and report nonconforming conditions, and are encouraged to participate in quality improvements to meet the needs of the customer and to achieve the objectives of the project mission.
- Strong emphasis is placed on line supervision leadership, accountability, and the implementation of quality tools at the line level.
- Management is responsible for providing the necessary resources for conducting root cause analysis and for implementing corrective and preventive actions.

3.4 Performance Cause Analysis

3.4.1 Supplier Performance

Supplier performance problems are identified and reported through the mechanism of Quality Control Reports (QCRs), generated by the Material Control Department's Incoming Inspection group for items such as incoming parts, assemblies, and supplied purchased hardware. These reports are reviewed and approved by the responsible authority/physicist (or designee) of the area or activity in which they will be used and by the Material Control Department Head (or designee). The review will

cover problems that may have significant programmatic effect or risk factors affecting cost, schedule, ES&H (personnel safety), or configuration. The appropriate disposition is given, i.e. scrap, return to vendor for replacement, rework at vendor, rework in house, or use as is. These reports are reviewed for supplier performance problems or trends and are used as a basis for cause analysis and necessary corrective action.

3.4.2 Work Process Performance

Discrepancy Reports have been developed and implemented to document problems during assembly or fabrication such as deviations, deficiencies, failures, defective items/materials or processes, malfunctions, trends, and/or non-conforming conditions.

The responsible authority of the activity or area of occurrence reviews these discrepancy reports for technical evaluation, cause determination, disposition, and corrective/preventive action recommendation.

Process Engineering performs a review of these reports to ensure that reports are completed properly and that preventive action is adequate; the QA Manager may also recommend follow up corrective/preventive action or verification/validation as required. These discrepancy reports are used as a basis for trends, cause analysis, and/or lessons learned.

4.0 Documents and Records

4.1 Policy

The policy of the Technical Division is to maintain adequate documentation and records to ensure quality requirements are met, while recognizing the objective of minimizing paperwork and cost.

4.2 Controlled Documents

4.2.1 Controlled documents are created, implemented, and maintained at a level commensurate with the level of work being performed and as dictated by sound quality assurance practices.

4.2.2 The TD maintains the following documents under document control:

- CMS-CSC Quality Assurance Plan
- Released Engineering Drawings and Technical Specifications
- Production Travelers

4.3 Documents and Records Responsibilities

4.3.1 Quality Assurance is responsible for the release, revision, and distribution of the CSC QA Plan.

4.3.2 The Engineering and Fabrication department is responsible for the control of documents and data pertaining to engineering specifications, engineering procedures, drawings, and travelers; and for the control of documents and data regarding CSC testing.

4.3.3 The Material Control Department is responsible for the control of documents and data associated with the procurement of materials for the assembly of the chambers.

4.4 Documents and Records Procedures

4.4.1 All controlled documents:

1. Are reviewed and approved by authorized personnel prior to being issued/revised.
2. Have a revision history maintained.
3. Are available to all personnel who need access.

4.4.2 All records are maintained in accordance with section 4 of the TD Quality Management Program (TD-2010).

5.0 Work Processes

5.1 Policy

The Technical Division's policy is that work processes be well thought out, appropriately documented and reviewed, and that they be carried out by competent and effective workers.

5.2 Responsibility

5.2.1 The CSC Project Site Manager's responsibility, as defined in 1.5.1, includes administering, planning, organizing, and controlling the CSC Project to meet the project technical, cost, and schedule objectives. In particular, the CSC Project Site Manager strives to encourage effective human resource management with the goals of hiring and maintaining an efficient and effective work force.

5.2.2 The individual CSC worker is the first line in ensuring quality. They are responsible for following the procedures defining the assembly and quality control checks in the fabrication of the chambers, i.e. travelers. They also have the authority to report any possible nonconformities to management, and may participate in cause analysis and continuous improvement.

5.2.3 The Department Heads are responsible for ensuring that people who assigned to tasks have the appropriate academic qualifications, professional certifications, or skills and experience to carry out the work successfully.

5.2.4 The CSC Project Site Manage, the CSC Project Engineer, and other project staff, as appropriate, are responsible for planning, authorizing, and specifying (to an appropriate level of detail), the conditions under which work is to be performed. This includes the calibration of measuring and test equipment (see section 8). This group also specifies which work is sufficiently complex or involves sufficient hazard to be performed to written procedures.

5.2.5 The Engineering & Fabrication Department is responsible for the inspection and test status, identification and traceability, and for the creation and maintenance of the travelers for the chambers (see 5.4).

5.2.6 The Material Control and Engineering & Fabrication Departments share responsibility for the handling, storage, and preservation of chamber components and completed chambers.

5.3 Production Process Control

Attachment IV defines the workflow for the fabrication of the chambers.

The EF Department Head, in conjunction with the CSC Site Manager and CSC Project Engineer, is responsible for ensuring that production processes are carried out under controlled conditions. When planning the production processes, the following are considered:

- All applicable government safety and environmental regulations
- Use of travelers (or other such work instructions) to document the methods of production. These should be used when the absence of such procedures could be adverse to quality.
- Defining suitable equipment and work environment to ensure quality.
- Defining suitable maintenance of equipment to ensure continuing process capability.
- Defining the criteria for workmanship in the clearest practical manner. Examples of this are work instructions that document tolerances for process parameters, samples or pictures of "quality" product, samples or pictures of poor quality or failure modes to look for.
- Level of education and experience required for production operators.
- Training needs for production operators.

5.4 Production Travelers

A system of travelers is used to define the sequence of fabrication, inspection, and testing to be performed for the chambers. Witness/Hold points are designated in travelers at a turning point or important juncture of the fabrication. Travelers provide for sign-off by qualified personnel and are dated at the completion of each fabrication sequence, welding operation, and inspection/test procedure by designated inspection/test personnel, fabrication personnel, or welding personnel to assure completion, date completed, and sequence of required operations.

Training of project personnel in the usage of travelers is accomplished with a "walk-thru". The "walk-thru" training is conducted by Process Engineering and Production lead personnel. The initial training simulates an actual operation (e.g. panel winding) using the traveler in a step by step sequence. The goal of the initial training is to familiarize all personnel with the proper usage of travelers in general, as well as to help everyone understand how the particular operation is designed to be completed.

Subsequent training of traveler revisions may be accomplished by communicating the changes to the appropriate Production personnel (this communication may be written or verbal).

5.5 Identification, Traceability and Test Status

All finished chambers are identifiable with names and serial numbers that are located on the unit and it's accompanying travelers. Sub-components are identified with either a label, and/or the accompanying traveler.

It is the Division's policy to maintain traceability on all production parts. For the CSC production, only panels (part numbers 368225, 368226, 368227, and 368228) and 50μ wire (part number 368019) have complete traceability maintained. All other parts do not have complete traceability maintained. This means that the parts kits are mainly used to ensure that the appropriate parts and counts of parts are correctly delivered to the production facility. It should be noted that completed parts kits forms eventually are married with the travelers, but *these parts kits should not be used for traceability purposes.*

Test status of completed chambers and sub-assemblies is identified either with a label and/or the accompanying traveler.

6.0 Design

6.1 Policy

The policy of the Technical Division is to ensure that designs perform as intended. This is accomplished by incorporating sound engineering/scientific principles and appropriate technical standards into designs.

6.2 Requirements

The CSC Project Site Manager and CSC Project Engineer implement the design policy. The CMS Title I Design Report (the CMS design handbook) has been independently reviewed in order to assure compliance with this policy.

The chambers fabricated at Fermilab must fulfill the requirements defined in the CMS design handbook. Any changes to the chamber design, as defined in the handbook, must be reviewed and approved by the appropriate level of management (see section 8 of the US-CMS Project Management Plan, Project Management System).

6.3 Drawings and Specifications

Formal drawings are generated and stored through the Engineering and Fabrication Department, and these drawings are reviewed and approved by the appropriate level of management.

6.4 Design Reviews

At appropriate stages of design, formal documented reviews of the design results are planned and conducted. Participants at each review include representatives of all functions concerned with the design stage being reviewed, as well as other qualified personnel (this may include ES&H). These reviews are completed in order to:

1) Identify potential problem areas or inadequacies;
2) Assess issues affecting safety and quality;
3) Initiate corrective/preventive actions;
4) Ensure that the design minimizes ES&H impact and satisfies all FNAL ES&H policies and external codes.

Results from the reviews are used as a basis for verifying that design stage outputs meet the design stage input requirements.

6.5 Design Validation

Designs are validated through the testing of the complete prototype system (or subsystem) during and after assembly, against the performance specifications. This testing includes the utilization of a cosmic ray test stand.

6.6 Design Changes

Appropriate design controls are incorporated into the CSC project by using configuration management. The change management mechanism, defined in section 8 of the US-CMS Project Management Plan, is used by the CSC project.

Proposed changes that affect the life, performance, reliability, or integration with other sub-systems, are reviewed and dispositioned by the Configuration Control Group (L2 and L3 managers). In order for the new design to be approved, the initiator must convincingly demonstrate that either the old design is not adequate, or that the new design has superior performance and/or cost advantage(s) over the old.

7.0 Procurement

7.1 Policy

The Technical Division policy is to ensure that items and services provided by suppliers meets the requirements and expectations of the end-users.

7.2 Requirements

The Fermilab contract with the DOE specifies a variety of management controls to be applied to procurements and sub-contracts through the applicable DOE orders, DOE Acquisition Regulations (DEAR), and Federal Acquisition Regulations (FAR). To this end, all procurement activities are performed in accordance with the *Fermilab Procurement Policy and Procedures Manual* and the *Fermilab ES&H Manual*.

Only approved material will be used in the production of the CSC's. The Material Control Department has the responsibility of procurement for the Technical Division and the CMS-CSC project.

7.3 Supplier Qualification and Selection

Suppliers are evaluated and selected on the basis of their ability to meet subcontract requirements. These requirements are appropriately defined in approved Engineering Drawings and Technical Specifications, and include specific quality assurance requirements.

Topics that are usually evaluated include, but are not limited to:

- Quality assurance program
- Ability to meet all requirements
- Cost
- Financial solvency
- Work history

7.4 Budget Authority

The Division Head, in conjunction with the budget defined by the CMS Project Office, assigns expenditure level to individuals responsible for a specific work package. Procurement of items and services that are above the stated expenditure level require Division Head review and approval. Attachment II defines proposed expenditure levels.

8.0 Inspection and Acceptance Testing

8.1 Policy

The Technical Division policy is to ensure that all items, components, and services meet the specified requirements. This is verified through the use of inspection and acceptance testing.

8.2 Requirements

As defined in section 5.2.4, the CSC Project Site Manager and the CSC Project Engineer define the types of work that require formal inspections and acceptance testing. When an inspection or acceptance test is performed, the characteristics and processes to be inspected or tested, the inspection techniques to be used, the hold points, and the acceptance criteria are defined, as appropriate.

Inspection and acceptance testing (to include receiving, in-process, and final) are performed in accordance with proper training and/or written procedures.

The Material Control Department works with the CSC Project Engineer to define and document receiving acceptance testing for incoming materials. The production travelers define the testing during the assembly of the chambers (in-process). The final inspection will include a sample of chambers undergoing testing in a cosmic ray test stand.

Properly calibrated (traceable to NIST) and maintained measuring and test equipment are used for all testing.

8.3 Records

To allow for traceability, adequate records are maintained for all inspections and tests. These records include observations made, inspection/test results, and identification of the personnel conducting the inspection/test, date, and time.

9.0 Management Assessment

9.1 Policy

The Technical Division's policy is to regular assess the Division's effectiveness in meeting it's objectives, goals, and compliance to orders and regulations. This is accomplished using the Technical Division Self-Assessment Program.

9.2 Requirements

Technical Division management will evaluate the TD's role in the CMS Project, in order to ensure the Division's continuing suitability in fulfilling the requirements of the CMS Project.

9.3 Methods

Details from the TD Self-Assessment Program are not repeated here. Assessments are made using formal and informal meetings and other communications. Examples are:

- Division Head meeting with Department Heads or other supervisory staff
- Department Heads meeting with line supervisors and other lead personnel
- Suggestions and recommendations from project personnel
- Design Reviews & Production Readiness Reviews
- Independent assessments (see Section 10.0)

9.4 Feedback

Information gathered during management assessments is used to provide feedback to the CMS Project personnel. This information will allow project personnel to make improvements and any necessary corrective/preventive actions, so that the goals of the CMS Project may be met.

10.0 Independent Assessment

10.1 Policy

The policy of the Technical Division is to utilize independent, i.e. third party, audits to ensure the Division's effectiveness in meeting it's objectives, goals, and compliance to orders and regulations.

10.2 Requirements

The CMS Project will be audited and evaluated by a third party, as needed. The audit(s) are used to insure that the quality management system is effective in achieving the stated mission.

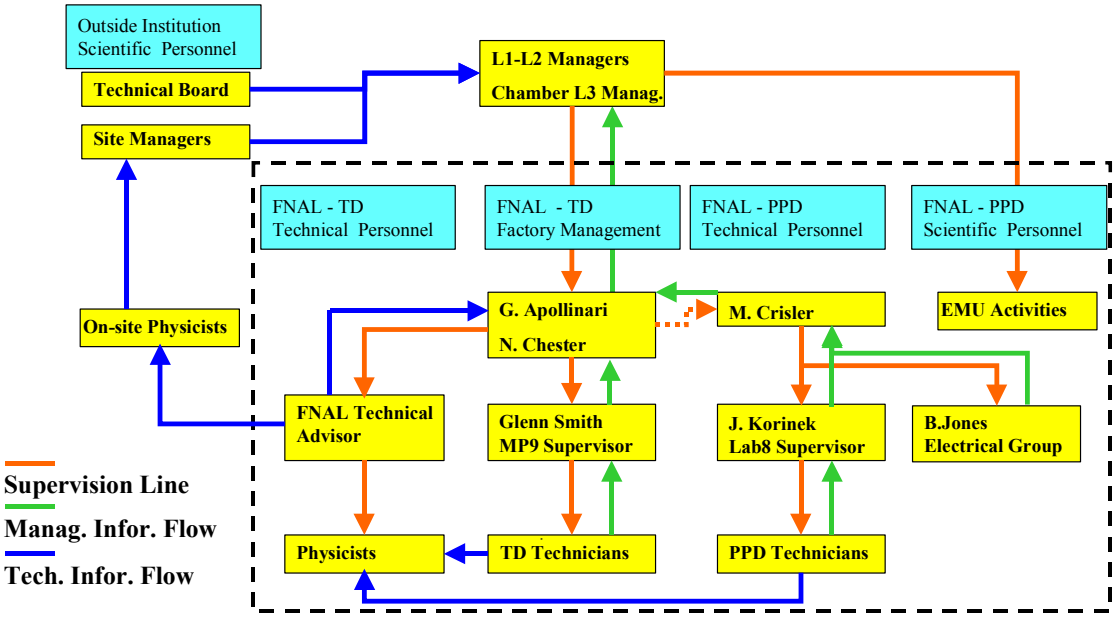
In order to evaluate the quality management system on a regular basis, an audit plan will be created and implemented by management. When performing the audits competent technical personnel will be utilized as auditors. These auditors are independent of the specific activities or areas being audited. Management, having responsibility in the area audited, and to assure corrective action and involvement of personnel of the specific areas of the audit, will review documented audit results.

10.3 Responsibilities

The Quality Assurance Officer is responsible for coordinating independent assessments and, as team leader and spokesperson, will provide leadership, guidance, audit procedures, and audit plans.

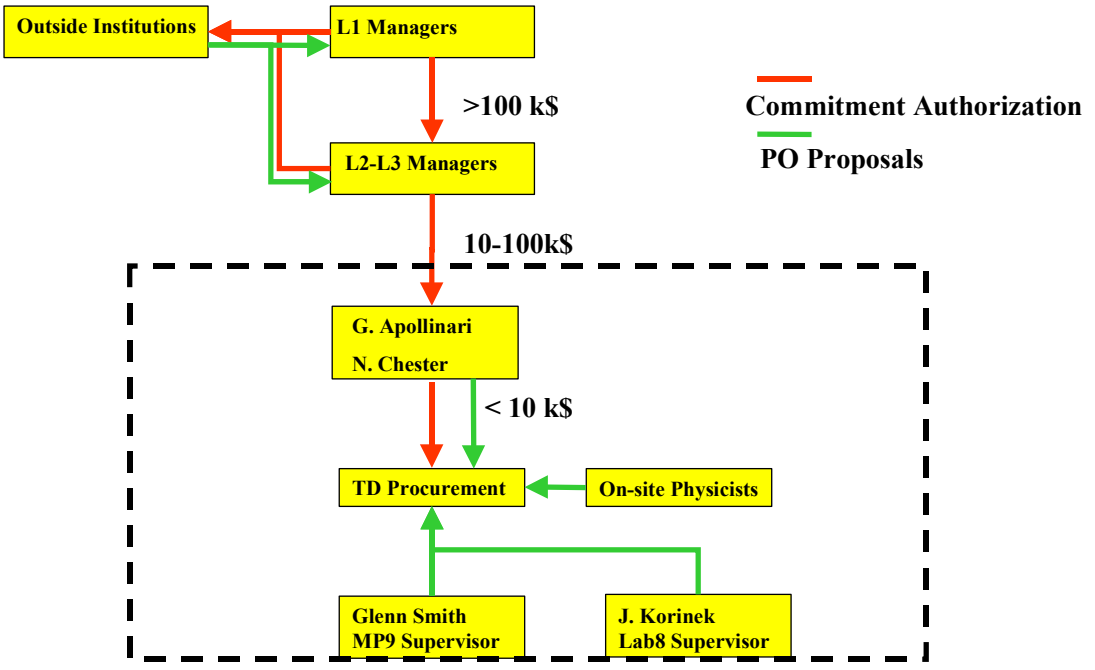
ATTACHMENT I

EMU Chambers Production Supervision Lines @ FNAL



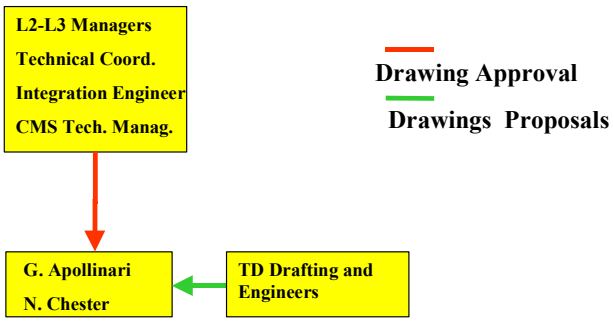
ATTACHMENT II

EMU Chambers Production Commitment Authorization PO Proposal



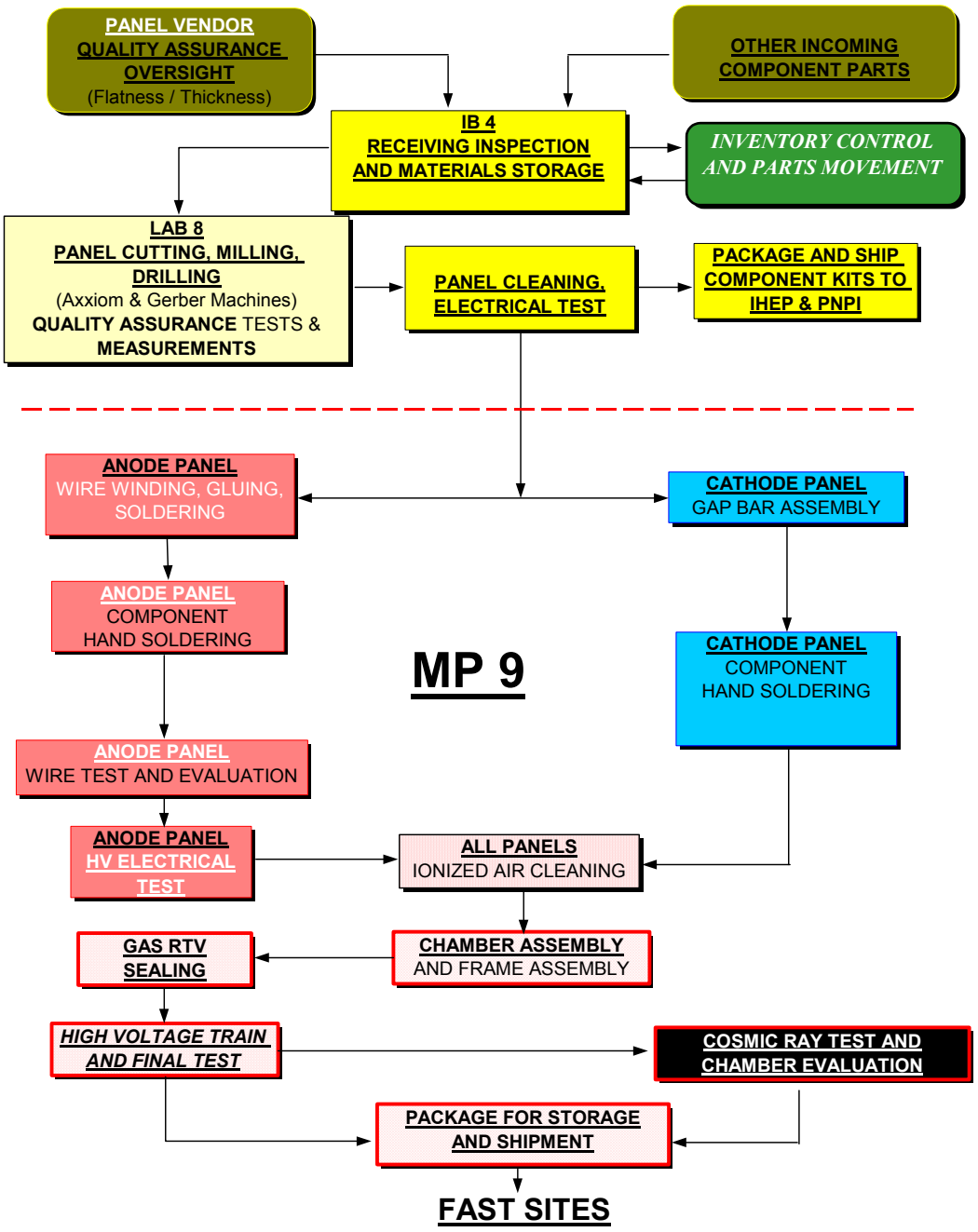
ATTACHMENT III

EMU Chambers Production Drawings Approval



ATTACHMENT IV

Fermilab Plan
CMS Muon Chamber Production
Production Flow



Revision History

Version	Date	Section No.	Specifics
1	08-18-2000	All	First version
2	14-Feb-2002	4.4.2 5.3/5.4 5.5	"All records are maintained in accordance with the TD Quality Management Program." Replaced term "Quality Control Traveler" with "traveler". New section as a result of audit TD-2002-01.

Controlled Distribution

Technical Division library	
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